Lockheed AIRCRAFT CORPORATION
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PERFORMANCE

The A-11 configuration is capable of 2,000 n. mi. radius mission cruising at Mach 3.2 at altitudes from 88,700 feet to 100,000 feet. The mission is summarized on Figure 1 and a distance-weight profile is shown on Figure 2. Airplane performance is summarized on Figure 3.

The mission comprises a full power take-off, climb and cruise. Fuel allowance for take-off and acceleration to climb speed is one minute at full power.

The climb performance is shown on Figure 4. The sea level rate of climb is 23,900 feet per minute and decreases with altitude to about 4,000 feet per minute at 74,000 feet. This part of the climb is made at a constant EAS of 400 Knots and an increasing true speed. Consequently a large part of the excess thrust is required for acceleration. Above 74,000 feet the climb is made at a constant Mach 3.2 and all of the excess thrust is available for climb. At 74,000 feet the rate of climb exceeds 30,000 feet per minute and thereafter decreases rapidly to zero at 88,700 feet, the start of cruise. The climb uses 9,000 pounds of fuel, covers 220 n. mi., and requires 10.67 minutes.

The climbing cruise is made at maximum power at Mach 3.2. The cruise time is 2.1 hours including a 180 degree turn at the target point 2,000 n. mi. from take-off at an altitude of 94,300 feet. The end of cruise is at 100,000 feet over the base at Mach 3.2. An actual mission would include an idle

PERFORMANCE (CONT.)

power descent starting 150 to 200 n. mi. from the base and would use less fuel than continuing the cruise to the base at altitude. Idle power operation of the engines at altitude is not yet established making the descent characteristics difficult to define. A reserve allowance is included for a single engine 30-minute loiter at subsonic speeds at 35,000 feet altitude.

The take-off and the landing ground roll are 2,400 and 2,700 feet respectively. Speeds required for take-off and landing are based on an angle of attack of 11 degrees, which is the clearance angle with the main gear struts compressed. This provides an adequate ground clearance margin over the 15 degrees provided with the gear struts extended. Single engine safety during take-off is excellent since the total airplane drag is less than 20,000 pounds including dead engine and trim drag and the operating engine provides about 30,000 pounds of thrust. Single engine performance during landing is, of course, better due to the reduced weight.

In the event of an engine failure at some point during a mission, two courses of action are open to the pilot. He can descend to about 50,000 feet and subsonic speed and return to base from any point during the mission. Or, he can maintain his speed at Mach 3.2 and descend to 72,000 feet. At this flight condition, he can return to base if the engine failure occurs not over 1,800 n. mi. from base on the outbound leg or not over 1,400 n. mi. on the return leg of the mission. Between these points the airplane cannot return to base. If the engine failure occurs at the target, the airplane

PERFORMANCE (CONT.)

will run out of fuel 350 n. mi. short of the base. The single engine supersonic return capability is shown on Figure 5. If penetration is assumed to occur at the end of climb, 220 n. mi. from base, then the airplane can make a supersonic single engine return to the penetration point from all points during the mission except within a distance of 70 n. mi. before reaching the target and 220 n. mi. after passing the target. Thus a high degree of multi-engine reliability is assured.

FIGURE 1

A-11 MISSION SUMMARY

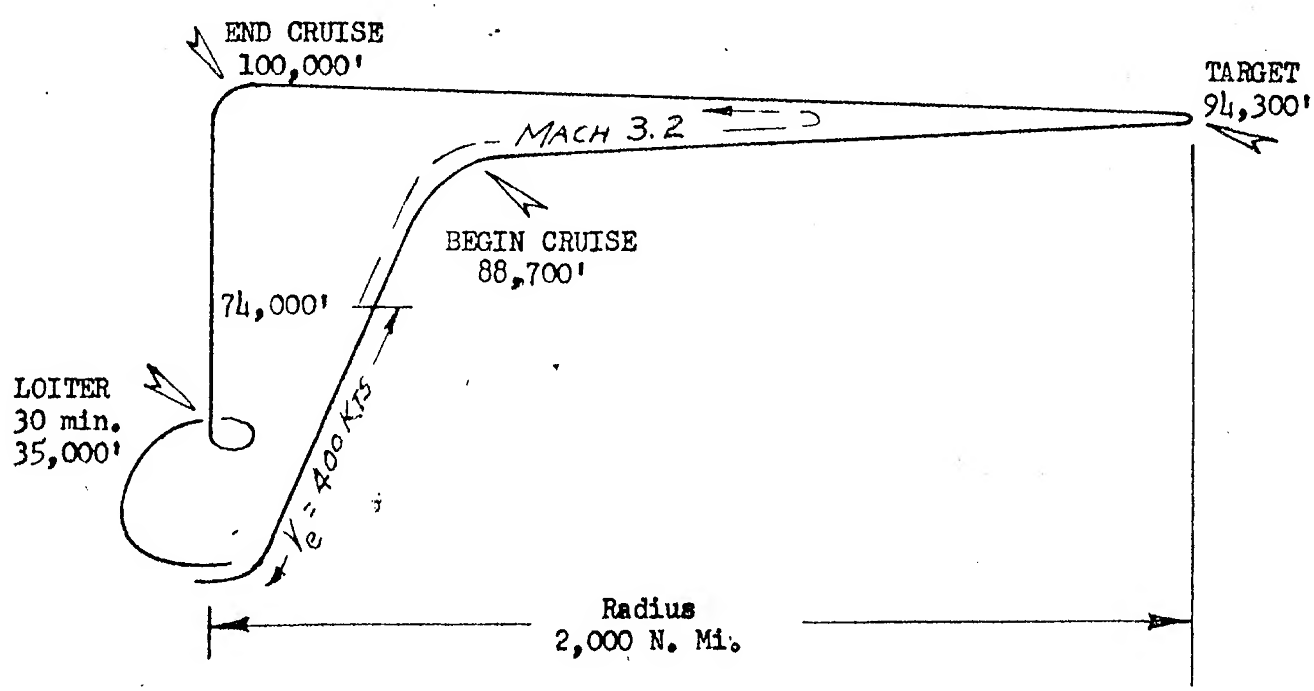
	Weight Lbs.	Fuel Lbs.	Dist. N.Miles	Alt. Ft.	
T. O.	84,800	1,700 ✓	0	S.L.	92130
Climb	83,100	9,000	220	S.L.	
Cruise Out	74,100	19,600	1,780	88,700	
Target	54,500	-	-	94,300	
Cruise Back	54,500	15,900	2,000	100,000	
Reserve (30 min.)	38,600	1,800	-	35,000	
ZFW	36,800	-	-	-	

Radius 2,000 N. Mi. (180° turn at target)

Fuel 48,000 lbs. Total
(31,000 lbs. HEF used in afterburner,
17,000 lbs. JP150 used in primary)

48

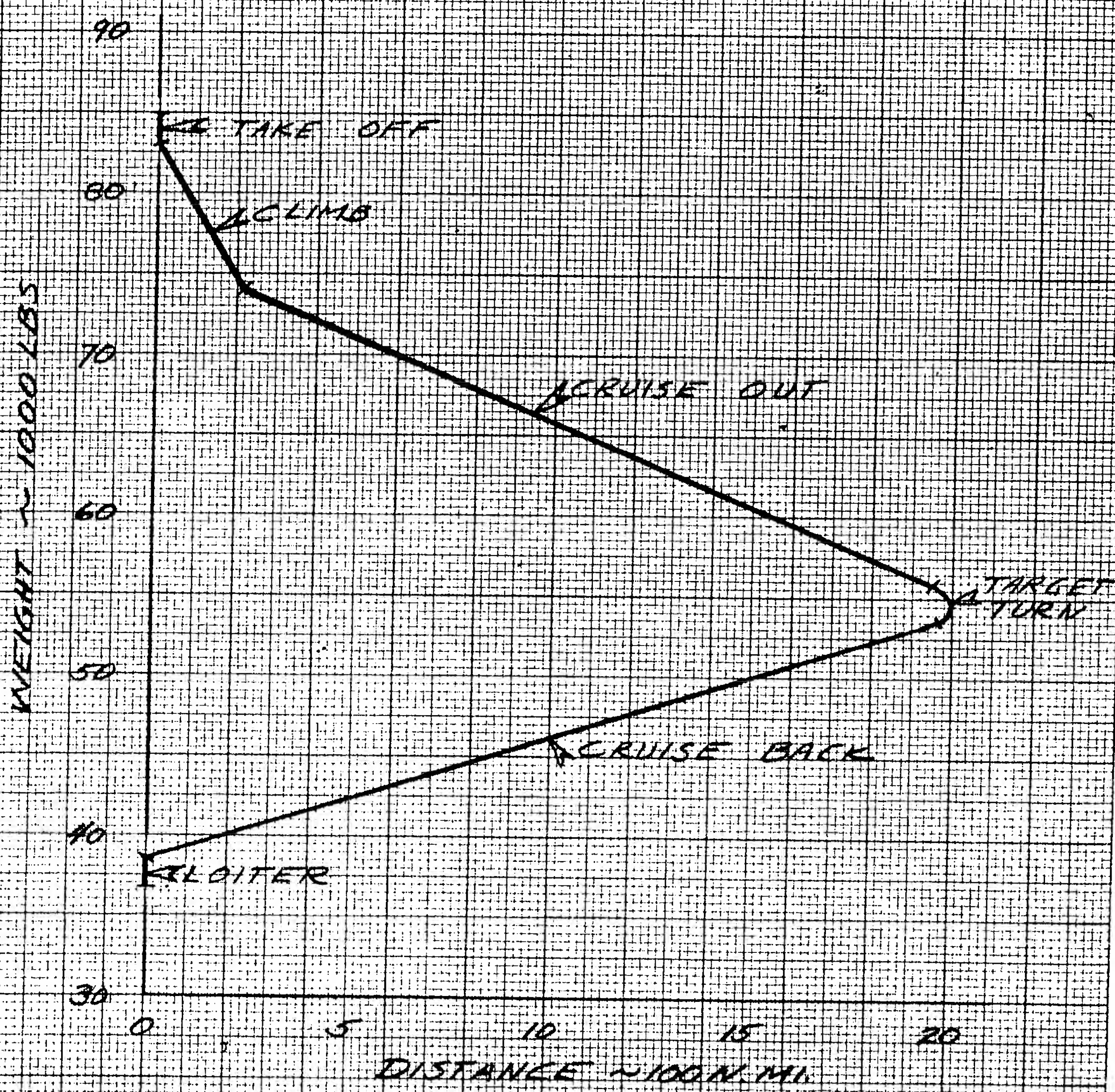
55,370



A-11

FIGURE 2

WEIGHT - DISTANCE PROFILE



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A-11 PERFORMANCE SUMMARY

Radius	2,000 n. mi.
Take-off	
Weight (lbs.)	84,800
Speed (Kts)	185
Take-off Ground Roll (Feet)	2,400
Rate of Climb at S.L. at 400 Kts. (Ft./Min.)	23,900
Cruise	
Mach No.	3.2
Speed (Kts)	1,890
Altitude (Feet)	88,700 to 100,000
Target	
Altitude (Feet)	94,300
Weight (lbs.)	54,500
Landing	
Weight (lbs.)	38,600
Speed (Kts)	125
Distance (Feet)	2,700

A-11

FIGURE 4

CLIMB SUMMARY

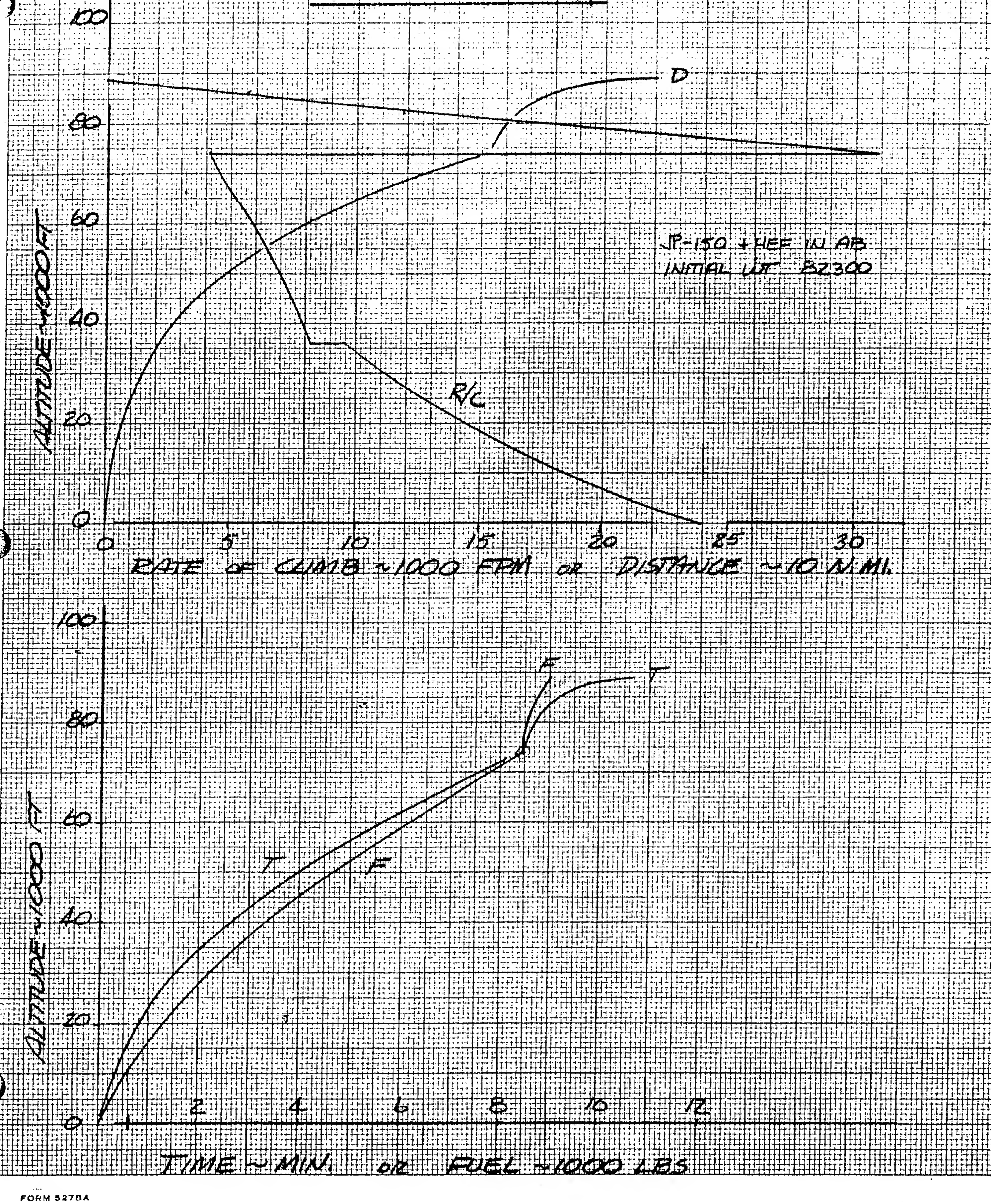
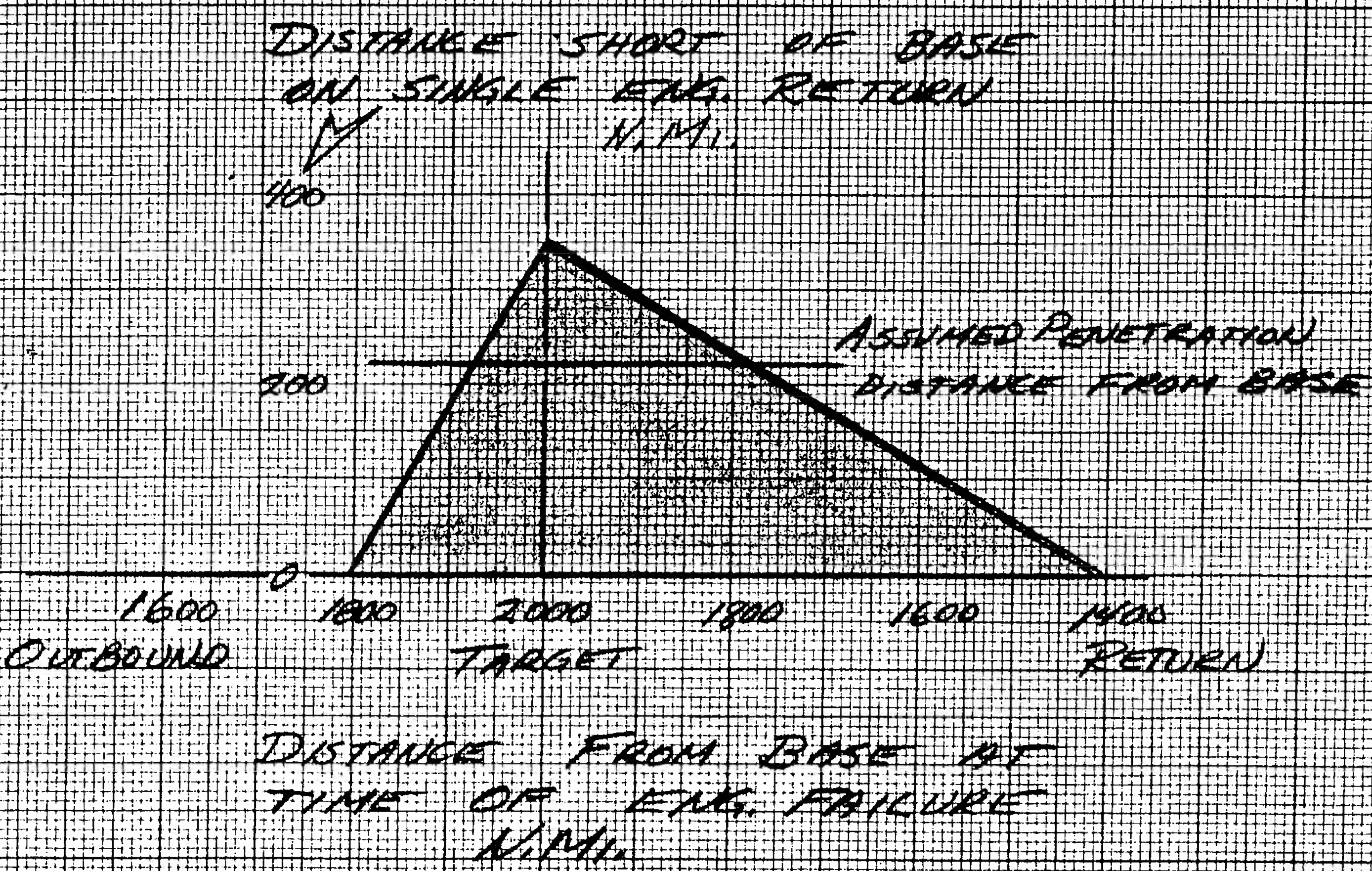


FIGURE 5

SINGLE ENGINE RETURN
CAPABILITY
MACH 3.2
72000 FT.



SECTION IV - STRUCTURAL DESCRIPTION

Item	Page
Weight and Balance	IV - 2
Design Loads	IV - 9
Material Selection	IV - 14
Structural Design	
Wing	IV - 16
Fuselage	IV - 28
Landing Gear	IV - 35

WEIGHT AND BALANCE

This section contains a brief discussion of the weight estimate and the airplane balance. The configuration achieves by structural simplicity the lightest airplane to perform the mission. The weight estimate is based on the use of present day production techniques and good weight control activity in design. Sufficient analyses have been made of the structure and major aircraft systems to determine the validity of the component weights; these analyses are the basis for the weight estimate.

The airplane balance is shown on Figure 1. The center of gravity envelope is tailored to give minimum trim penalty during the supersonic position of the mission, while retaining reasonable c.g.'s for take-off and landing. The most forward c.g. is at take-off, as fuel is used the c.g. moves aft to give the most aft c.g. at the mid-point of the mission and then forward for landing.

Page 3 contains the weight summary followed by a brief discussion of the component weights on pages IV-5 to IV-8.

WEIGHT SUMMARY

Wing	9,430
Fin	1,450
Fuselage	4,550
Landing Gear	1,900
Surface Controls	1,120
Nacelles	1,900
Propulsion Group	13,110
Instruments	110
Hydraulics	550
Electrics	300
Electronics	425
Furnishings	150
Air Conditioning	750
Tail Parachute	70
Weight Empty	35,815
Oxygen	40
Oil	60
Unusable Fuel	100
Pilot	285
Payload	500
Zero Fuel Weight	36,800
Fuselage Fuel	30,925
Wing Fuel	17,100
Take-off Weight	84,825

CENTER OF GRAVITY ENVELOPE

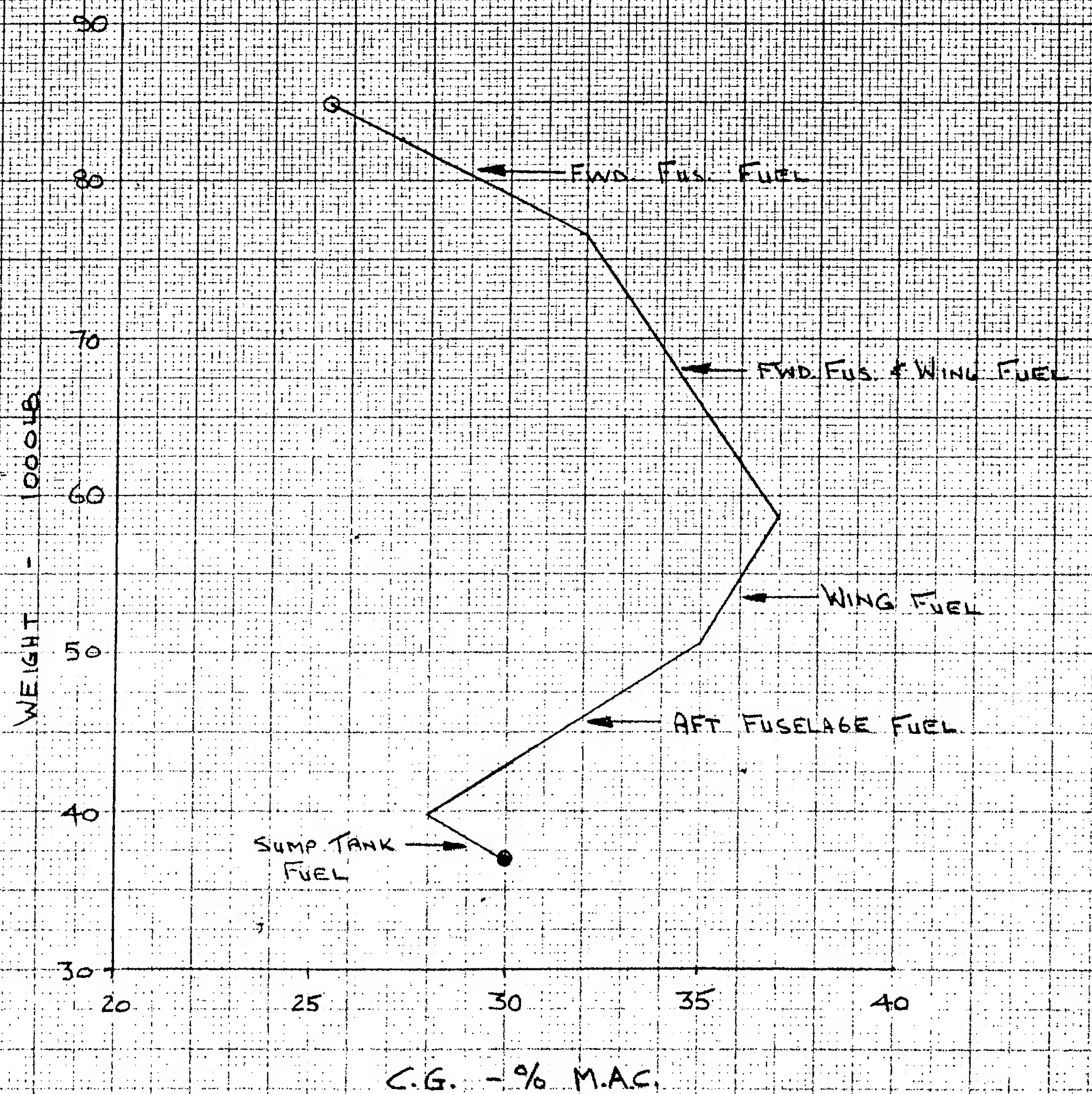


FIGURE 1

WEIGHT AND BALANCE

Component Weight

The wing and fuselage weights are derived from the structural analyses briefly presented in this section of the report. The fin structure will be the same type as the wing, reduced in weight due to the lower load intensities.

Wing

Box Beam

Skin Panels	3,000
Beam Caps	1,390
Beam Webs	780
Ribs	1,150
Joints etc.	380
	6,700
Leading Edge	1,020
Trailing Edge	1,480
Fillets-Wing to Fus.	230
Total	9,430

Fin

Fin	1,450

Fuselage

Skin	1,225
Longerons	670
Frames	705
Wing & Fin attachments	350
Landing gear support structure	250
Bulkheads	190
Joints etc. in Shell	340
Windshield & Canopy	250
Doors - Equip. Bay, Gear, etc.	470
	4,550

WEIGHT AND BALANCE

Component Weight (Cont.)

Landing Gear

Main

Wheels and Tires	380
Brakes	320
Struts, Retraction, etc.	850
	1,550

Nose

Wheel and Tire	110
Strut	180
Steering and Retraction	60
	350

Surface Controls

The surface control weight is based on full powered irreversible systems. An allowance of 50 lbs. is included in the autopilot weight to provide any stability augmentation that may be required.

Cockpit Controls	45
Autopilot	150
Elevon System	675
Rudder System	250
	1,120

Nacelles

The total weight of this group is 1,900 lb. and includes the air intake system and engine cowl. The engine cowl, that is the portion aft of the front face of the engine, is estimated to weigh 900 lb. The air intake

WEIGHT AND BALANCE

Component Weight (Cont.)

Nacelles (Cont.)

system as drawn is somewhat tentative since the inlet configuration will probably require some development, however, the weight of 1,000 lb. allowed seems adequate for anything that can be envisaged at this time.

Propulsion Group

The J-58 engine weight of 5,950 lb. each includes starting provisions and self contained oil system. The fuel is contained in integral wing and fuselage tanks, the simultaneous use of JP-150 and HEF will require some ingenuity in the design of the fuel system plumbing to minimize the weight penalty for this feature. The additional weight of 200 lb. carried for the HEF system is based on some duplication of pumps, distribution and transfer systems.

Engines		11,900
Engine Controls		50
Fuel System		1,160
Tank Sealing	350	
Basic System	610	
HEF Increment	200	
		13,110

Instruments

Flight Instruments	25
Engine Instruments	40
Misc. & Installation	45
	110

WEIGHT AND BALANCE

Component Weight (Cont.)

Hydraulics	550
Electrics	300

Electronics

This group includes the navigational and communication equipment described in Miscellaneous Systems section together with the wiring and supports required to install these systems in the airplane.

ARC 62 Command Set	75
ARN 44 Radio Compass	85
Inertial Navigation System	200
Driftsight	35
MA1 Compass	30
	425

Furnishings

Ejection Seat	100
Oxygen System (fixed items)	15
Misc. Consoles & Trim	35
	150

Air Conditioning

The air conditioning problem is discussed in Cockpit Environment section. The weight allowance of 750 lb. for this system is a reasonable estimate at this stage.

DESIGN LOADS

Loads used for the structural design of this airplane are based on the requirements of Military Specification MIL-S-5700 with modified gust criteria. The gust criteria modification refers to the variation of gust velocities with altitude as shown by Figure 4.

Figure 3 shows the variation of design speeds with altitude. Above 72,000 feet, maximum speed is limited to M = 3.2. From 72,000 feet to sea-level the maximum design speed is 425 knots, EAS. The design level flight speed of 370 knots, EAS shown on this chart was selected for combination with a ± 50 fps. gust. Calculated aileron reversal speeds are also shown on Figure 3. Adequate wing stiffness within the design speed range is indicated by these reversal speeds.

V-n diagrams for gust and maneuver are shown by Figure 2. For the maneuver envelope maximum accelerations of +2.5 g and -1.0 g are used. The gust envelope shown is conservatively based on zero-fuel weight of 36,800 lbs. and therefore, results in the maximum design gust load factors.

Ultimate design loads for the various airplane components are included in the pertinent sections of this report. Except for the forward part of the fuselage, a 2.5 g sub-sonic maneuver @ T.O. weight of 85,000 lbs. produces critical loads on both the wing and fuselage. The +50 fps. gust condition @ 36,800 lbs. produces slightly higher loads on the forward

DESIGN LOADS (Continued)

part of the fuselage. A 2.5 g maneuver @ M = 3.2 is not critical because fuel used to climb reduces the gross weight to 75,000 lbs. Wing loads for this condition are approximately 86% of the "cold" condition loads. Fuselage loads for this condition are not critical because the fuel used is removed from the forward fuselage tanks.

V-n DIAGRAMS

GUST ENVELOPE FOR 36800 LBS @ 25,000 FT
MANEUVER ENVELOPE FOR 36800 LBS

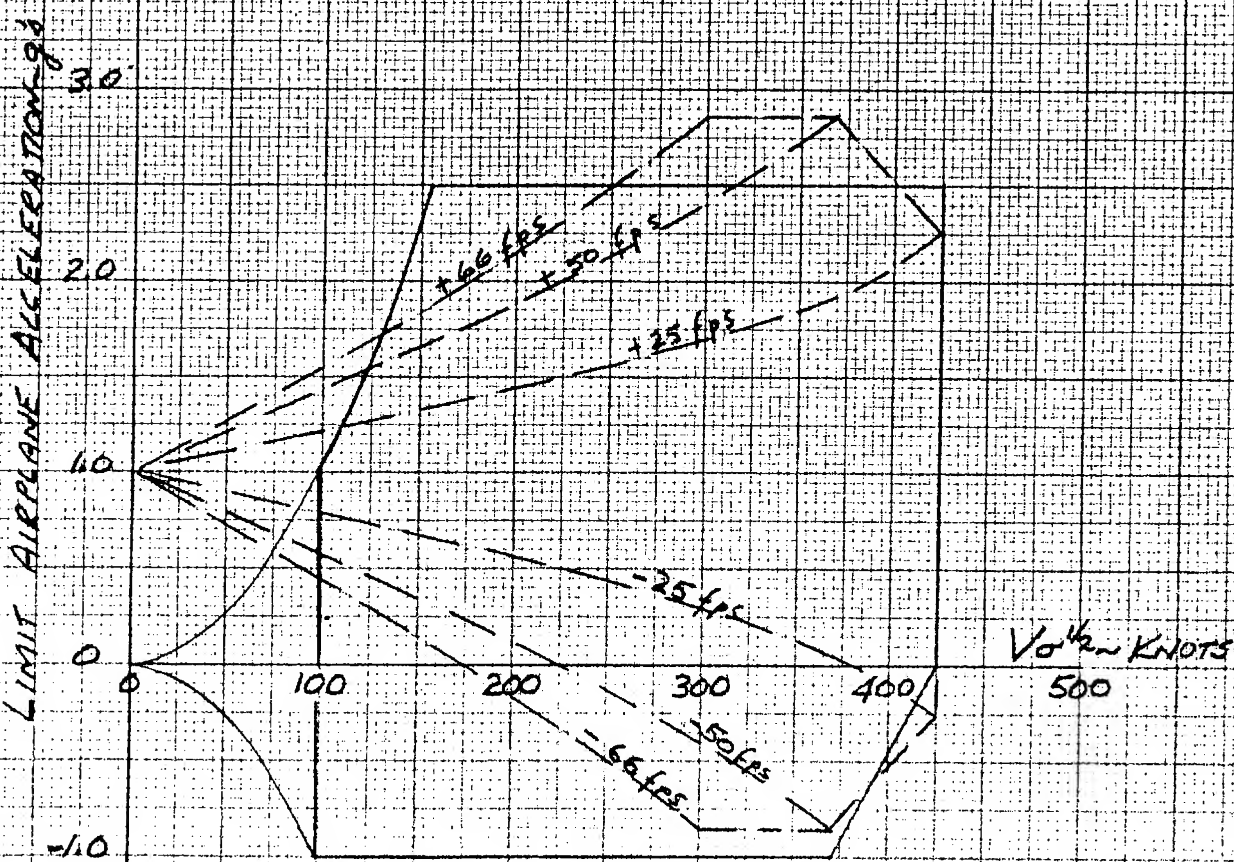


FIGURE 2

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MODEL A 11
REPORT NO.

SPEED- ALTITUDE CHART

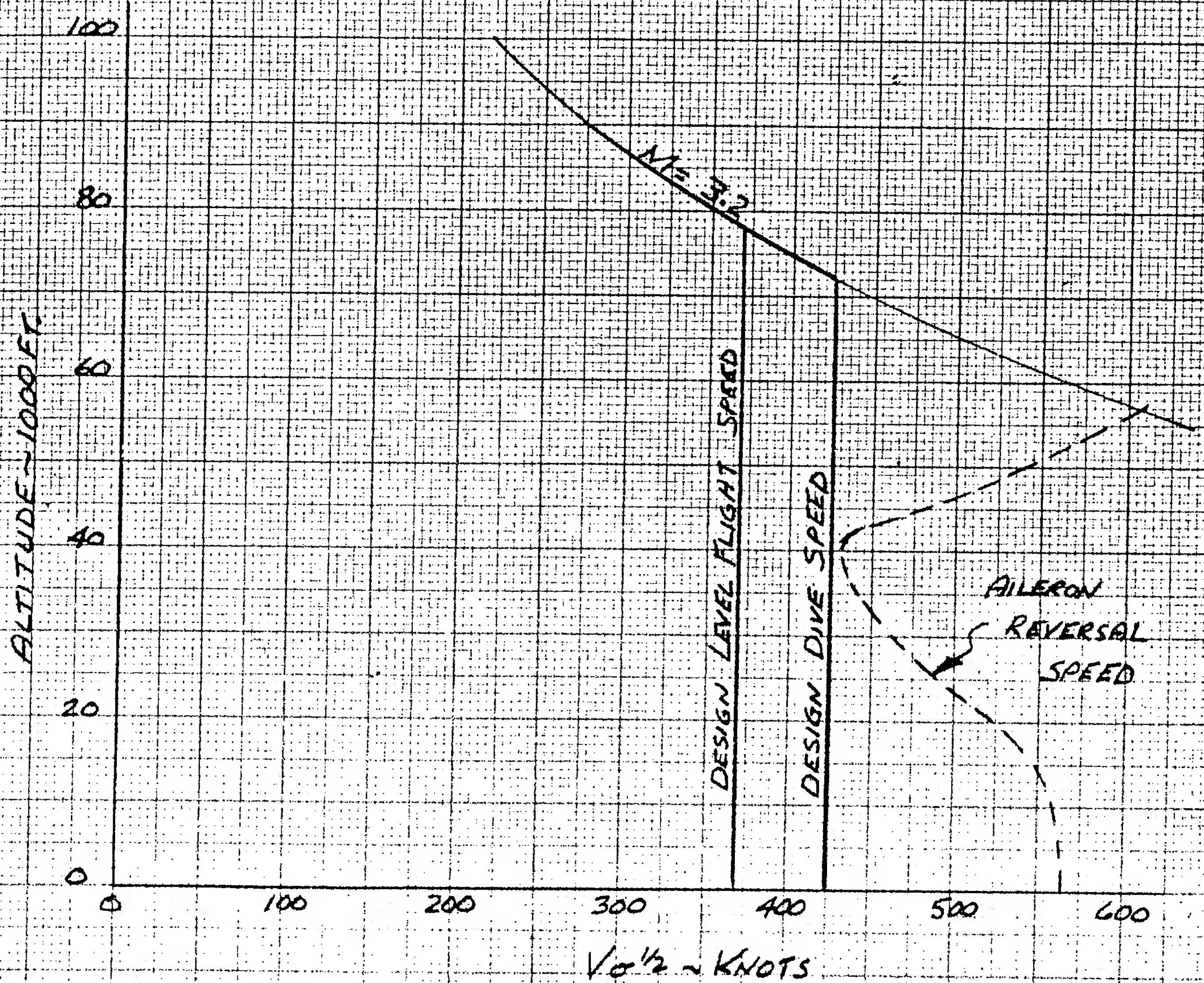

FIGURE 3

DESIGN GUST VELOCITIES

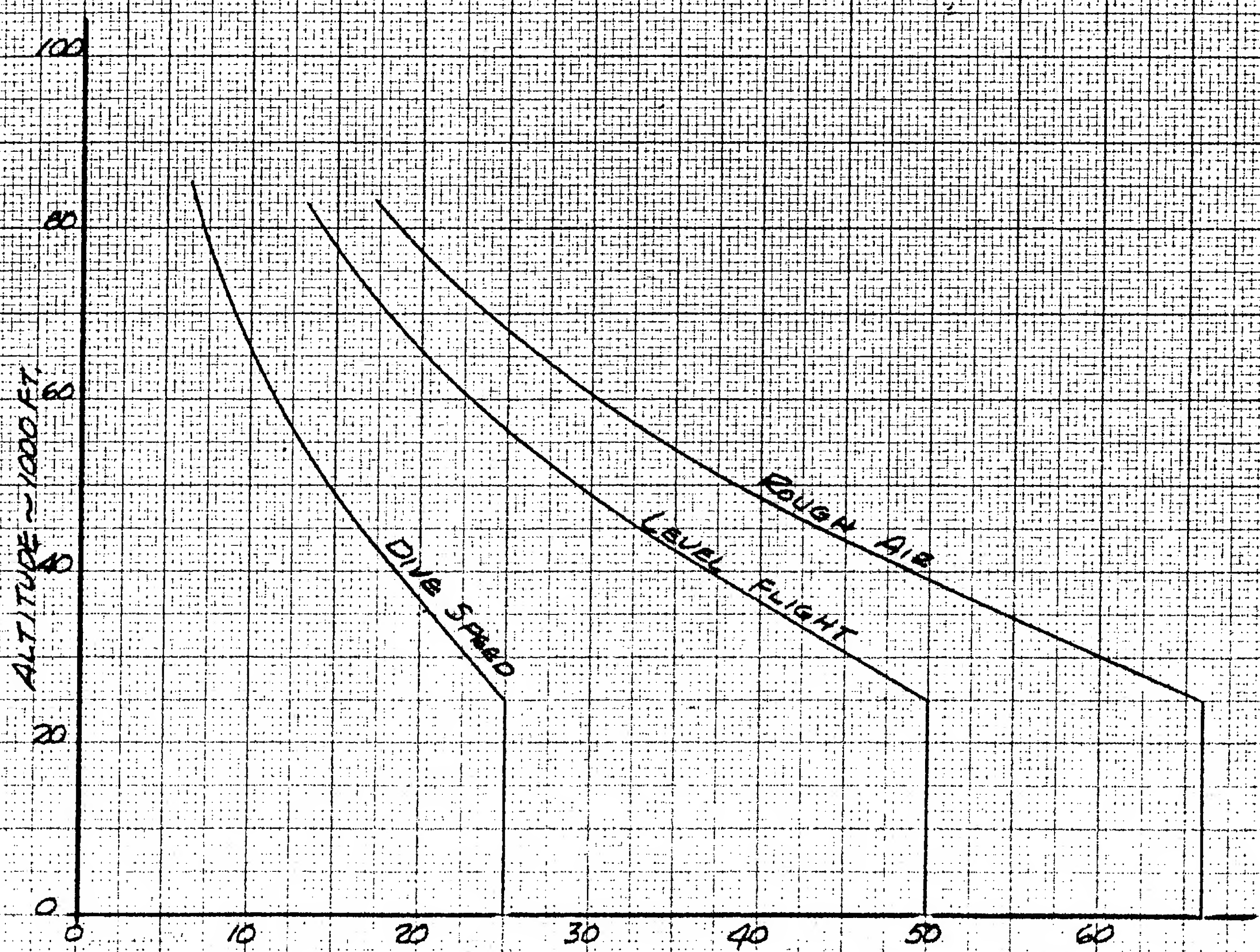

FIGURE 4

MATERIAL SELECTION

Investigation was made into new experimental materials available and those still being developed in the laboratory. All of the common and exotic metals and modifications thereof were considered. These were compared to each other on strength/density basis, for ultimate, yield and modulus of elasticity, for all temperatures up to 1200°F. For temperatures up to 800°F titanium alloys indicated as good as or better strength/density capabilities. Of the titanium alloys considered MST 185 and B-120VCA were shown to be most promising.

From feasibility and producibility aspects B-120VCA is the most practical and the most efficient in strength at all temperatures up to 800°F. The material selected is manufactured by Crucible Steel Corporation, Pittsburgh, Pennsylvania, and is basically an all Beta titanium alloy. Its elements are 13% vanadium, 11% chromium and 4% aluminum. It can be purchased in the annealed, aged, or cold worked and aged conditions. Aging is a simple heating procedure (800°F - 1000°F) for extended periods of time ranging from 8 to 100 hours, followed by air cooling.

This material indicates the following characteristics:

1. Good bendability and formability.
2. Good weldability.
3. Non-directional characteristics.
4. Ability to be brazed.

MATERIAL SELECTION (Continued)

5. Cold headability.
6. Readily machined.
7. Exceptionally low creep rates at elevated temperatures.

The physical properties of solution treated or annealed material are as follows:

1. Density: 4.82 GMS./c.c. (0.175 lbs./cu.in.).
2. Specific Heat: .131 BTU/lb./°F.
3. Thermal Expansion: 5.2×10^{-6} in./in./°F (68 - 200°F)
4. Thermal Conductivity: 3.90 BTU/hr./Ft.^{2}/°F/Ft.

The mechanical properties furnished by material vendor are as follows:

Annealed	Room Temp.	600°F
F_{t_u} - psi	152,000	109,000
F_{t_y} - psi	151,000	103,000
% Elong.	12	21
Elastic Modulus - psi	14.3×10^6	13.2×10^6

Aged	Room Temp.	600°F
F_{t_u} - psi	200,000	175,000
F_{t_y} - psi	190,000	145,000
% Elong.	5	9
Elastic Modulus - psi	15.3×10^6	13.8×10^6

MATERIAL SELECTION (Continued)

The above values have been verified by a number of coupon tests in the Lockheed Research Laboratory.

General temperatures expected throughout the airplane structure are expected to be 500°F with peak temperatures on leading edges equal to 780°F. The above allowables indicate this material has good mechanical properties in this range.

WING

Description

The construction of the wing is as shown in Figure 5. The structural box extends from 15 percent to 80 percent of the wing chord. Forward of 15 percent, the leading edge consists of a solid leading edge arrowhead and skins supported by multiple ribs and stiffeners perpendicular to the swept leading edge. The structural box itself consists of multiple beams sapced at 16 inches along the chord. Beams are built up of beam caps, webs and stiffeners. Caps are located under contour in order to allow for the passage of surface corrugations in a chordwise direction. Shear attachment of beams to outside skin is accomplished by tabs between corrugations. The beams are designed to carry the wing beam bending load and vertical shear.

The surfaces of the box consist of an outer skin and an inner corrugated skin with corrugations running in a chordwise direction. This surface structure is designed to carry normal pressures to the beams and to resist wing torsional moment. This type of surface design, acting together with intercostal ribs spaced approximately 40 inches along the span, provides good chordwise form stiffness.

Aerodynamic heating of the structure results in a temperature gradient from outside skin to inside structure. This gradient can be accommodated by this type of structure easily since expansion of the outside surface results only in buckling or waving between corrugations in the streamwise direction.

WING (Continued)

Description (Continued)

Hence, the stresses due to temperature gradient are held to a minimum and aerodynamic smoothness is maintained.

For producibility and transportability, a joint in the wing is provided just outboard of the engine nacelle as shown in Figure 5. The trailing edge structure from 80% to 100% of chord consists mainly of control surfaces.

Material throughout the wing is B-120VCA titanium in various forms.

Design Loads

Ultimate wing shear, bending moment and torsion is shown in Figure 6 for critical 2.5 g heavy weight condition. This is a room temperature condition at M = 0.8. Supersonic "hot" conditions are 14% less and are not critical on the box structure since the material reduction factor at 500°F is only 10%.

Section Properties

The airfoil section is presented graphically in Figure 7. Using this section and the wing basic dimensions, the structural section properties are calculated and presented graphically in Figure 8.